BIRKINBINE (H.P.M.)

FUTURE WATER SUPPLY

OF

PHILADELPHIA.

BY HENRY P. M. BIRKINBINE, M. E.

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FUTURE WATER SUPPLY OF PHILADELPHIA.

BY HENRY P. M. BIRKINBINE, M. E.

Read before the Franklin Institute at its meeting October 15th, 1879.

I have had the honor of reading two papers before the Institute upon the "Future Water Supply of Philadelphia."* In the first paper some of the available sources were examined: the Schuylkill, Delaware and the Perkiomen; their volume and the present and prospective comparative purity of the water compared. In the second paper the means now used and those proposed for securing a supply from these sources were presented and analyzed.

It was, no doubt, evident to those who heard these papers, or who have read them, that one object in presenting them before the Institute was to demonstrate the practicability and desirableness of securing a supply of water for the city of Philadelphia from the Perkiomen by gravitation, a project reported upon and recommended to the Councils of Philadelphia in 1866.

I have been requested to read another paper upon this important subject. The request has, no doubt, been prompted by the interest created by several articles in the daily papers and the able article upon the "Future Water Supply of Philadelphia," by James F. Smith, C.E., in the last number of the JOURNAL (October).

After waiting so many years it is a source of gratification to have the public endorsement of this project by an engineer of the standing and long experience of James F. Smith, C. E., whose duties as the engineer of the Schuylkill Navigation Company have made him personally acquainted with this particular region and with the storage and supply of water from streams in the drainage area of the Schuylkill.

While the Commission of Engineers, appointed in 1875 to report upon a better supply of water for Philadelphia, gave the Perkiomen gravity plan their unanimous approval, they suggested so many other plans that it is hard to decide what they did or meant to recommend by their report.

I fully acknowledge my obligations to Mr. Smith personally, and as

* See JOURNAL OF THE FRANKLIN INSTITUTE for May and July, 1878.

a citizen of Philadelphia, for the great amount of care and attention he has bestowed upon the consideration of this important subject, and the valuable information given to the public in his article. Statements made by an engineer of his standing and experience will be accepted without question, as they should be; and yet there may be facts in connection with the subject which have not come under his notice, or conclusions, based upon the representations of others, which may be incorrect. It is for the purpose of making some explanations and adding a few additional facts that this paper is presented for your consideration.

In the water supply of a city the head under which the water should be furnished, and the quantity required, are among the most important points to be settled, and this should be done before any work is undertaken. These questions are readily answered by asserting that the greater the head or pressure and the larger the volume the better. This is true in the main, but there are circumstances and conditions which modify and restrict both of these essentials to a practical limit, and the proper head and quantity become, therefore, important subjects of inquiry.

The head or pressure of the Fairmount reservoirs is but 96 feet above city datum, 54 feet above the highest and 84 feet above the lowest grade of the streets, and as these furnish the most densely populated and the business centres of the city, an augmented head would be of great advantage.

After a careful examination of the entire area covered by the city it was found that a reservoir at an elevation of 170 feet would command almost the whole area, and that the parts lying at a greater altitude would necessitate another system of about double this elevation, leaving a few small districts demanding a still greater height. It was therefore decided that a supply furnished at an elevation of 180 feet would meet the requirements of the city better than any other head. This pressure or force would not be too great for the old pipe system and would be sufficient to reach the upper stories of the larger buildings, and would give a more satisfactory supply through the fire hydrants. This being settled, the next question was, how large a supply must be provided to meet the prospective demands of the city—a more difficult one to answer, as no one can predict what the future of this city may be—and if, as some assert, it is destined to become the London of this continent, and its inhabitants counted by millions, it would

require corresponding works. It was thought better to forecast the future by the history of the past. In 1865 it was found that the demand for water had more than doubled in ten years, and was then an average of over 30 million gallons per day; from this it is estimated that 150 million gallons per day would furnish an ample supply for the increase at that rate for at least 25 years, or until the city numbers between two and three million inhabitants. But this rapid increase will scarcely be realized, and it is probable that the above quantity (150,000,000 gallons) will furnish a copious supply for the next half of a century. The increase in the number of gallons of water supplied in 1875, as compared with 1865, was nearly 37 per cent. The amount supplied for the year 1878 was an average of nearly 53,000,000 gallons per day. These two factors were then adopted as a basis, and the surveys and examinations made for the purpose of securing a minimum supply of 150 million gallons per day, delivered into a reservoir in the city at an elevation not less than 170 feet above city datum. Surveys were made of all the streams of any importance within thirty miles of the city. The Delaware River was also examined as far up as the Water Gap.

The Perkiomen was found to possess all the requirements of quantity and elevation, and, so far as present and prospective comparative purity of the water, it was equaled by none of the other sources examined. This stream was, therefore, recommended.

A most desirable location was found for an impounding reservoir, not at as great an elevation as desired; but the location admits of the construction of a dam of almost any height. As it is neither necessary nor desirable that the inlet of the aqueduct should be placed at or near the bottom, it was only intended to draw the water for the city from the upper part of the dam, leaving the lower part for the accumulation of suspended matter brought into the reservoir with the water.

Surveys were made for the purpose of ascertaining if the minimum head, 170 feet, could be secured, and it was found that by raising the water by impounding 65 feet, the surface would be 204 feet above city datum, and cover 1500 acres. This would give ample head to overcome friction of the aqueduct, and allow the dam to be drawn down from 12 to 15 feet.

The bottom of the Croton aqueduct at the gate chamber is but 11·4 feet below the surface of the dam, and the Loch Katrine aqueduct

draws the lake down seven feet below its overflow. The height of the proposed dam need not be restricted to 65 feet; it can be made 100 feet deep, or deeper, if necessary.

It is to be regretted that no surveys have been made which would enable the actual location of a line of aqueduct, but from some little preliminary work and an examination of the country between the Perkiomen and the city, lines of aqueduct at the proposed elevation are practicable by several routes.

Being confident that the Perkiomen would be the source, and gravitation the mode of supply, at some time in the future, a reservoir was located in the 24th ward, George's Hill, north of the present reservoir, and was placed at an elevation of 180 feet, to form a part of this system of supply. This was to have been constructed by shutting up the end of the ravine along Belmont avenue, thus forming an artificial lake which would have stored 225 million gallons and cost but one-half as much as the reservoir built in its stead, which stores but 30 million gallons. It is true, the surface of the water in the present basin is 32 feet higher than the one proposed and commenced would have been. This greater elevation commands but a very small additional area, and is not of sufficient altitude for the high lying portions of this district. The change in location has not only given the city a much smaller reservoir, at a largely increased cost, but entails an annual expense for pumping the water to an unnecessary height, which in 1878 amounted to $7,121.46.

This, then, is what was supposed or intended to be done by the Perkiomen project:

Objections Answered.

Mr. Smith's objections to the original site selected for the construction of the impounding reservoir are, first, as follows: "It will be observed the conduit from the lake was not designed to deliver water into the receiving basin in the city at a greater elevation than 133 feet above city datum." This conclusion is arrived at from statements in the report of the Commission of Engineers; but it has been demonstrated by actual surveys that a dam of but 65 feet in depth would deliver water by gravitation into a reservoir in the city 170 feet above city datum, and allow the water in the proposed lake to be drawn down 12 feet. These facts have never been controverted, and the Commission of Engineers used the same figures; therefore it is evident that they proposed to loose 47 feet in the declivity or fall of

the conduit to the city; an unnecessary head, as Mr. Smith's calculations demonstrate. He estimates a loss of 25·94 feet in the entire length of his proposed conduit, or 0·94 feet per mile. The fall in the Croton aqueduct, New York, is from 0·504 to 1·106 feet per mile. The fall in Cochituate aqueduct, Boston, is but 0·45 feet per mile, including the pipe conduit; in Loch Katrine aqueduct it is 0·833 feet per mile, and in the Washington aqueduct 0·792 feet to the mile. I proposed to use a fall of 20 feet, or 0·727 feet per mile, in bringing in the water of the Perkiomen.

From the above it is evident that the first location has sufficient elevation, and it was designed to supply all the reservoirs in the city with the exception of the Roxborough and Mt. Airy, which have an altitude of 365 feet. This location was also selected by the Commission of Engineers, who proposed a dam ten feet deeper than the surveys for the minimum proved to be necessary.

An inspection of the contour map prepared by the Water Department shows that a reservoir with the water surface 180 feet above city datum will practically supply the entire city, so that the proposed additional head of 60 feet will be of little actual value, as it would only supply a narrow strip, lying between an elevation of 130 and 190 feet, not three square miles in area. This additional pressure would make it necessary to empty 95 per cent. of the water into and supply it from reservoirs of less elevation, as the head on the low lying districts would be unmanageable and destructive to the old pipe systems.

The reservoirs known as the Schuylkill, Delaware, and Corinthian avenue, when considered as a part of the water supply of a great city, are of little importance on account of their limited storage capacity. The ground they occupy, and the increased value their removal would give to the property in their immediate vicinity, would go far towards paying for a reservoir of ample capacity at a proper elevation. These should therefore not stand in the way of an arrangement which would place practically the entire city under one system of supply. If it has been demonstrated that the location for the dam on the main stream of the Perkiomen above Schwencksville has a sufficient head, then the objections on that account may be considered as answered.

The second objection is "the great length of the mound dam." When you are informed that a dam 1100 feet long on the top will raise the water 65 feet and cover 1500 acres, and that the storage capa-

city of the first 12 feet below the overflow would be 5,000,000,000 gallons, and that the foundations and abutments of the dam will be of solid rock, you will see that it will be difficult to find a more desirable location. That suggested by Mr. Smith was examined for a supplementary or feeding reservoir when the demands of the city would make one necessary.

The third objection "is the value of the property submerged and expense of removing the railroad." When my surveys and recommendations were made no railroad existed in the valley. The surveys for a railroad were not made until after mine were completed. This is therefore not a question of engineering, but is simply one of comparative cost, and can only be settled when the value of the property overflowed, and the cost of the several dams which are proposed to take the place of the large one, and the increased length of the aqueduct, at least 4½ miles, have been ascertained; then it will probably be demonstrated that the original location would be the less costly, and it certainly is the most desirable. To carry an aqueduct at the proposed greater elevation would add much to its cost of construction and also to its length.

Points Settled.

The following important facts in regard to the Perkiomen plan may be claimed as demonstrated:

1st. The comparative purity and desirableness of the water. All who have examined it agree that in this most essential requisite it is now and likely to remain entirely satisfactory.

2d. That there is an abundant supply of water. Mr. McAlpine, one of the Commission of Engineers, estimated the daily average flow of the stream at 331,000,000 gallons. Mr. Smith, by adding the East branch, Indian Run and Towamencin Creek, estimates the daily average flow 272,265,752 gallons. His estimate leaves out six miles of the main valley.

Calculations based upon data in the "Report of the Park Commission" gives the daily average flow, at the point of the original location of the dam, 250,000,000 gallons.

My estimate was 240,000,000 gallons per day, without taking into account the East branch, Skippack, Towamencin, the Wissahickon or or any other stream the waters of which could be brought into the conduit on its way to the city.

There can, therefore, be no question but that from 150,000,000 to

175,000,000 gallons can be secured for a supply for the city after making all deductions for evaporation, soakage and waste of storm water; an abundant supply of water for a city of more than double the inhabitants Philadelphia now contains, with enough to supply the towns near which the line of aqueduct would pass, and sufficient for the city of Camden, should it desire to be supplied from this source.

3d. There is sufficient elevation to furnish all the city with water by gravitation from the first location, with but trifling exceptions, not amounting to over three per cent. of all the water required.

The strange indifference of the public in reference to this project, and the unwillingness of the municipal authorities to investigate it, make its advocacy embarrassing and almost hazardous to the reputation of an engineer; but after the unanimous endorsement of the Commission of Engineers and the pains taken by one of them, the most experienced in water works construction—William J. McAlpine—to present it somewhat in detail, with general plans and estimates, and the endorsement, after a thorough examination of the subject, by Mr. James F. Smith, C. E., may we not hope that the project will at least be thoroughly investigated by our municipal authorities?

Efforts to interest leading men in the city government have been met with the reply of "What is the use of talking about it? the city cannot increase its indebtedness or undertake any enterprise of such magnitude." Yet since the Perkiomen project has been before Councils over five millions of dollars has been expended upon the enlargement of the water works. Some of this money has been worse than thrown away, and to-day the supply of water to the city is not as full, when the number of inhabitants is taken into account. Very few of the extensions are of such a character as to be of a permanent nature, and are only sufficient to meet the pressing necessities of the present demands. Such appears to be the policy for the future, and it will be necessary to make large appropriations almost every year for extensions.

A supply flowing into the city by gravitation would also save $150,000 per annum in cost of operating the works. It is therefore evident that the city can save nothing by pursuing its present policy in relation to its water supply. Works of the proposed character and capacity when completed will require no further expenditures for many years to come, and allow the burdened tax-payer rest, so far as

the demand for water works extension is concerned, for a generation or more.

The cross sections of the different aqueducts are:

BOSTON, COCHITUATE.—Brick conduit, oviform, 6 feet 4 inches by 5 feet. 14·627 miles long. Total fall, 3·74 feet.

MYSTIC POND.—Brick conduit, oviform, 5 feet by 5 feet 8 inches. 3000 feet long. Fall, 0·5 foot per mile.

SUDBURY RIVER.—7 feet 8 inches by 9 feet; 16 miles long; capacity, 70 million gallons per day; fall, 1·055 feet per mile.

NEW YORK, CROTON.—7 feet 5 inches by 8 feet 5½ inches; length, 38 miles; fall, 0·504 to 1·106 feet per mile.

BALTIMORE. *Old Aqueduct.*—Same as Cochituate; fall, 1 foot per mile; flow, 30,000,000 gallons per day; 4¾ miles long. *New Aqueduct.*—12 feet diameter, 7 miles long; fall, one foot per mile; capacity, 170 million gallons per day.

WASHINGTON.—9 feet diameter, 11½ miles long, fall, 0·792 feet per mile; capacity, 67 million gallons per day.

Using Robert K. Martin's formula, incorrectly printed in the JOURNAL of October, page 244,

$$V = \sqrt{\frac{180 \times \text{head in feet} \times \text{diameter in inches}}{\text{Length in feet.}}}$$

An aqueduct from the Perkiomen to the city, 26 miles long, 14 feet diameter, with a fall of 20 feet, will discharge 200 million gallons per day.

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